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THE RED SPIDER ON THE AVOCADO.

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CONTENTS.

INTRODUCTION.

The red spider *Tetranychus yothersi* McG. is one of the foremost enemies of the avocado and attacks a number of other plants and fruit trees in Florida. It was recognized by avocado growers as an important enemy of this fruit as early as 1909, and since that time the damage caused by it has become more pronounced each year. This bulletin records the work with this spider during the years 1918 and 1919 and the results of cooperative spraying experiments in connection with the station established by the Bureau of Entomology in 1917 at Miami, Fla., for the investigation of various insect enemies of the avocado and other subtropical fruits characteristic of that region.

ECONOMIC IMPORTANCE.

In groves where the red spider is abundant the trees frequently become defoliated prematurely during the winter season. This generally results in an abnormal development of bloom the following spring and the weakened trees are unable to set and hold a full crop

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of fruit. To sustain the bloom and aid in the setting of fruit the older foliage should remain on the trees until a sufficient amount of new growth apparently arising from the inflorescence (fig. 1) has been produced in the spring to take its place.

NATURE OF INJURY TO FOLIAGE.

The red spider punctures the leaves and sucks the contents, forming white spots at the point of attack. As these feeding punctures and

FIG. 1.—Avocado blossom cluster with older leaves which sustain the bloom, and developing new growth.

resultant white spots become more in evidence a gradual burning and reddening of the foliage results, as if scorched by fire (Pl. I, A, B). The foliage so attacked soon falls, giving the tree a naked appearance (fig. 2).

FOOD PLANTS AND DISTRIBUTION.

This red spider was first named and described by E. A. McGregor[1] from specimens on camphor (*Cinnamomum camphora*) leaves sent

[1] MCGREGOR, E. A. FOUR NEW TETRANYCHIDS. In Ann. Ent. Soc. Amer., v. 7, no. 4, p. 355–357, 1914.

A. Hoen & Co. Baltimore.

THE RED SPIDER OF THE AVOCADO

A, Avocado leaf with characteristic reddening and scorched appearance caused by the red spider; *B*, Uninjured avocado leaf.

him in 1914 by W. W. Yothers, of Orlando, Fla. The writer has found it attacking both the West Indian and Guatemalan varieties of avocados (*Persea gratissima*), being particularly injurious to the more tender West Indian types. It occasionally causes considerable injury to the mango (*Mangifera indica*) and in many sections of northern Florida to the camphor and Australian silk oak (*Grevillea*

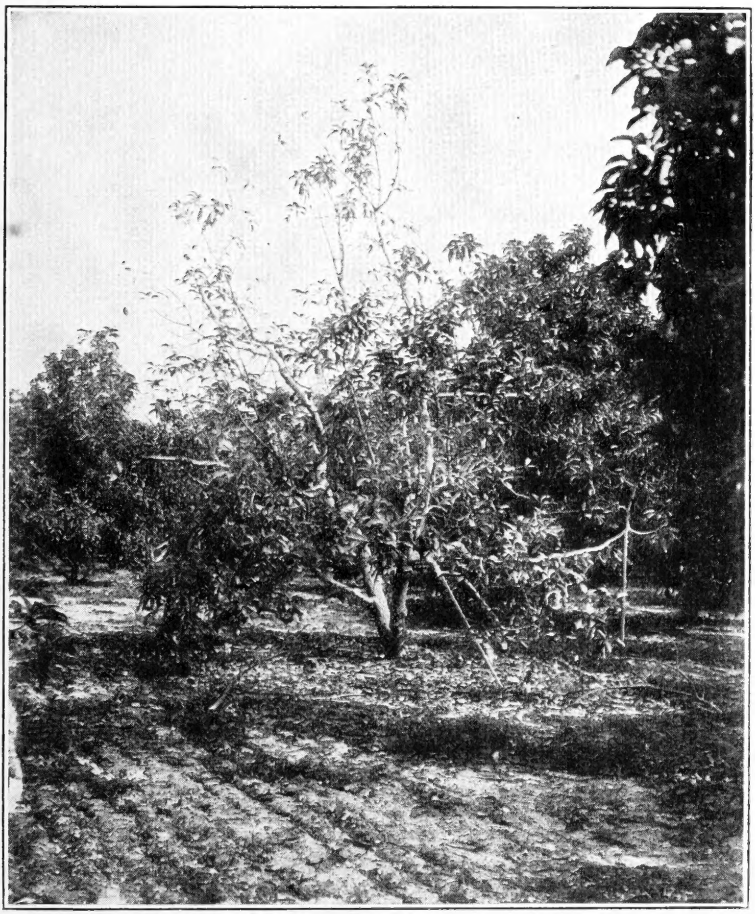

FIG. 2.—Defoliated avocado tree during midwinter, the result of attacks on foliage by the red spider.

robusta), to the foliage of which it imparts the same discoloration that it causes to the avocado. It has also been collected in Florida on a species of eucalyptus (*Eucalyptus* sp.). In addition to these host plants, the writer has at times collected the red spider on *Terminalia arjuna*, *Annona squamosa*, *Cucumis sativus*, and *Ipomoea paniculata*—the latter a plant growing quite commonly in the hammocks of southern Florida.

Mr. E. A. McGregor reports it as attacking also the American elm (*Ulmus americana*) and two other varieties of elm (*Ulmus* spp.), the willow (*Salix* sp.), the white oak (*Quercus alba*), and the pecan (*Hicoria pecan*), at Batesburg, S. C. He records it also on elm (*Ulmus* sp.) from Columbia, S. C., and Laurinburg, N. C. These records indicate a probable wide distribution of this red spider through the South. In Florida the writer has found this species along both the east and west coasts, including Miami Beach, Miami, Biscayne Key, Homestead, West Palm Beach, Florida City, Fort Myers, Bradentown, Oneco, and Winter Haven.

DESCRIPTION AND HABITS.

THE ADULT FEMALE.

In appearance the adult female (fig. 3, *f*) is similar to most red spiders which attack various other crops. It is small, of a rusty red

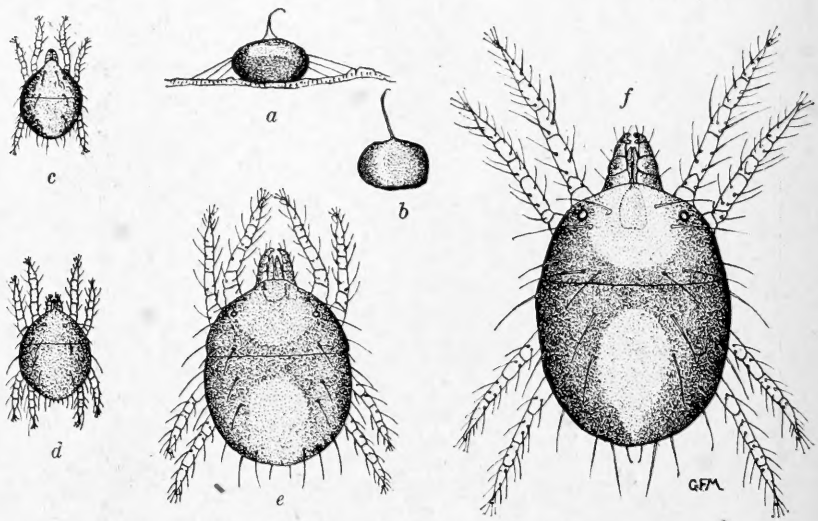

FIG. 3.—The avocado red spider: *a*, *b*, Egg; *c*, larva; *d*, first nymph; *e*, second nymph; *f*, adult female.

color, averaging 0.30 mm. in size. The abdomen joins the cephalothorax, formed by the fusion of the head and thorax, at its full width and extends over the portion to which the posterior pair of legs is attached. The body and legs are covered with bristles.

THE MALE.

The body of the male is slender and pointed toward the tip of the abdomen and is somewhat smaller than that of the female. The legs are slightly darker and longer than those of the female. The eyes are red and somewhat more conspicuous than those of the female. It averages 0.22 mm. in length.

THE EGG.

The egg (fig. 3, *a*, *b*) is globose in shape, smoky amber in color, and bears a stalk at its apex. Guy fibrils are occasionally seen connecting the egg with the leaf.

The eggs are deposited singly and when the leaf first becomes infested are generally found located along the midrib at the base of the leaf. As the activities of the mites increase with succeeding generations, the eggs may be found scattered over the entire leaf.

The incubation period varies according to the temperature and general climatic conditions. (See Table 1.) During midwinter, with mean daily temperatures between 60° and 70° F., incubation requires from 7 to 11 days. During April and May the incubation period averaged from 4 to 5 days with mean temperatures between 70° and 80° F., in rearing experiments with this species. In hatching, the shell of the egg splits more or less completely around and the larva easily extricates itself. During the height of the red spider season leaves will be observed heavily covered with hatched eggshells which adhere to the leaf and impart to it a whitish cast.

TABLE 1.—*Length of the egg stadium.*

No.	Date deposited.	Date hatched.	Duration.	Mean temperature.	No.	Date deposited.	Date hatched.	Duration.	Mean temperature.
			Days.	° *F.*				*Days.*	° *F.*
1	Oct. 15	Oct. 20	5	78	7	Jan. 21	Feb. 1	11	60
2	Oct. 22	Oct. 26	4	77	8	Feb. 15	Feb. 22	7	70
3	Nov. 8	Nov. 13	5	72	9	Mar. 15	Mar. 20	5	72
4	Nov. 30	Dec. 8	8	70	10	Apr. 1	Apr. 5	4	75
5	Dec. 18	Dec. 25	7	65	11	May 31	June 5	5	76
6	Jan. 1	Jan. 11	10	58	12	July 11	July 15	4	79

THE LARVA.

The newly hatched larva (fig. 3, *c*) is round, very light yellow, possesses six legs, and in size does not exceed that of the egg from which it emerged. It is very delicate, and a marked characteristic is its possession of conspicuous carmine eyes. During the process of development and feeding the young creatures commence to change color. The larva measures 0.17 mm. in length on an average.

As with practically all mites the larva stage is divided into an active and a quiescent period. The former is passed while the larva is feeding and the latter in preparation for the first molt. The time spent in the quiescent period of the larva stage averages in most instances only a few hours. The average length of the larval period is 2.58 days.

TABLE 2.—*Length of the larval stadium.*

No.	Date of hatching.	Date molted.	Duration.	Mean temperature.	No.	Date of hatching.	Date molted.	Duration.	Mean temperature.
			Days.	°*F.*				*Days.*	°*F.*
1	Oct. 18	Oct. 20	2	76	7	Feb. 1	Feb. 4	3	65
2	Oct. 28	Oct. 31	3	77	8	Feb. 22	Feb. 24	2	70
3	Nov. 15	Nov. 19	4	75	9	Mar. 20	Mar. 23	3	72
4	Dec. 10	Dec. 13	3	70	10	Apr. 5	Apr. 7	2	75
5	Dec. 25	Dec. 28	3	68	11	June 5	June 7	2	76
6	Jan. 11	Jan. 15	4	63	12	July 13	July 15	2	79

THE FIRST NYMPHAL STAGE (THE PROTONYMPH).

The first nymphal stage (fig. 3, *d*) differs from the larva in having four pairs of legs instead of three and is slightly increased in size. The extra pair of legs appears behind the last pair of legs of the larva. The segments of the legs become longer, as do likewise the bristles on the body and legs. The color of the body darkens. The abdomen in this stage becomes elongated as compared to the larva. The average length of the protonymph is 0.25 mm.

For the most part the habits of the nymphal stage are similar to those of the larva. As with the larval stage the protonymph stage is divided into an active feeding period and a quiescent period preparatory to molting. The average length for the first nymphal stage is 2.8 days.

TABLE 3.—*Length of the first nymphal stadium.*

No.	Date emerged.	Date molted.	Duration.	Mean temperature.	No.	Date emerged.	Date molted.	Duration.	Mean temperature.
			Days.	°*F.*				*Days.*	°*F.*
1	Oct. 20	Oct. 22	2	76	7	Feb. 4	Feb. 6	2	65
2	Oct. 31	Nov. 3	3	77	8	Feb. 24	Feb. 26	2	70
3	Nov. 19	Nov. 23	4	75	9	Mar. 23	Mar. 25	2	72
4	Dec. 13	Dec. 18	5	70	10	Apr. 7	Apr. 9	2	75
5	Dec. 28	Jan. 1	4	68	11	June 6	June 8	2	76
6	Jan. 15	Jan. 18	3	63	12	July 14	July 16	2	79

THE SECOND NYMPHAL STAGE (THE DEUTONYMPH).

The second nymphal stage (fig. 3, *e*) is similar to the first nymphal stage except that it is much larger and more elongate. In its full-grown condition, however, it resembles more the adult, though the color is not as deep a red. It averages 0.38 mm. in length.

The habits of the second nymphal stage are likewise similar to those of the larva stage. The average length for the second nymphal stage is 2.84 days.

TABLE 4.—*Length of the second nymphal stadium.*

No.	Date emerged.	Date molted.	Duration.	Mean temperature.	No.	Date emerged.	Date molted.	Duration.	Mean temperature.
			Days.	°*F.*				*Days.*	°*F.*
1	Oct. 22	Oct. 25	3	76	7	Feb. 6	Feb. 10	4	65
2	Nov. 3	Nov. 6	3	77	8	Feb. 26	Feb. 29	3	70
3	Nov. 23	Nov. 25	2	75	9	Mar. 25	Mar. 28	3	72
4	Dec. 18	Dec. 21	3	70	10	Apr. 9	Apr. 12	3	75
5	Jan. 1	Jan. 4	3	68	11	June 8	June 10	2	76
6	Jan. 18	Jan. 24	3	63	12	July 16	July 18	2	79

BIOLOGICAL DATA.

Webbing.—Unlike the majority of red spiders this species does not spin an extensive web and carries on its depredations on the foliage practically unprotected. The only indications of any webbing made by this species are the mere fibrils attached to the apex of the eggs when deposited (fig. 3, *a*).

Average length of life period.—The length of the life period of the adult mites varies greatly with the season and temperature and possibly other conditions. Experiments on the life history of this species showed that adults emerging November 25 came to their natural death during the period January 1 to 15, while those emerging June 10 succumbed between July 1 and 15. This shows that during the dry winter months approximately two months are required from the time of emergence to the completion of the life period, while during the humid summer months approximately a month is required.

Molting process.—Before molting the mite securely attaches itself to the leaf. In emerging from the quiescent stage the old skin splits transversely along the cephalothoracic-abdominal suture. Following the splitting of the skin the anterior end of the mite is slowly drawn from the old skin. With the use of its fore legs the mite forces its way out from the shell.

Parthenogenesis.—Some immature individuals were isolated on a number of plants. From these individuals virgin females were obtained. These females produced eggs and in each instance the resultant individuals were males.

Migration.—There does not seem to be an alternate host of this species. Individual red spiders may be found on the avocado at any time during the year in varying numbers, and never leave the tree for want of a new or alternate host plant on which to feed. In a grove the red spiders are spread from tree to tree by the wind, birds, etc.

Generations of the species.—The generations of the avocado red spider fluctuate as to number and overlap considerably. In years of little rain during the fall the red spiders come in evidence more quickly than when rains occur earlier. Intermittent rains frequently

occurring during the red spider season also interfere with the regularity of the generations. Activity of the red spider usually commences during the latter part of August and ceases the first part of April, giving an active season of about 240 days. The average duration of the life cycle is 14.2 days, which would give 17 generations. This would be true where no interruptions due to climatic conditions occurred, and when no other factors interfered with the normal activities of the mites in the field.

Shedding of the foliage.—During the winter months the foliage may be termed "dormant," no new growth being present on the trees. Usually during the latter part of March and April the avocado commences to bloom and the older leaves, which have served their purpose to the trees, commence to fall. With the shed leaves many mites are lost and do not regain positions on the trees. During the latter part

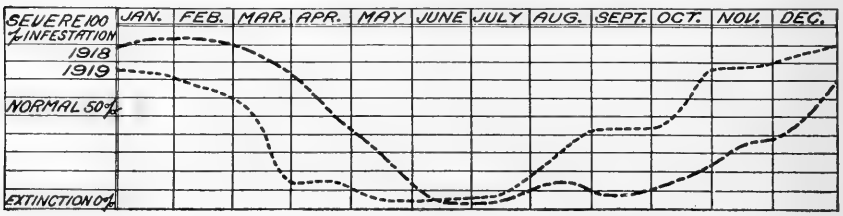

FIG. 4.—Curves showing 2-year composite seasonal status of the avocado red spider in southern Florida. The decimations arising through the amount of precipitation are the most important controlling factor in the activities of the species.

of April very little old foliage is present and a remarkable reduction of red spiders is apparent. A few old leaves, however, always remain on the trees until the newer growth has hardened and thus enable the red spiders to remain continuously on the trees and to infest the newer growth when it hardens.

Climatic control.—Climatic conditions existing in Florida influence the development and activity of the red spider to a marked degree. This particular species, as has already been stated, confines its depredations to the upper surface of the foliage. The species so working is exposed to the weather conditions. Hence during the period of the life cycle or seasonal cycle there is a series of fluctuations in numbers. In April, as the rainy season approaches, the red spider barely maintains existence. (Fig. 4.) During the months of June, July, and August no pronounced gain is made, but toward the latter part of October the avocado ceases to produce new growth, the red spiders commence to make their appearance in greater numbers, and increase during November and December. They usually reach the maximum number during January and February, and decrease again toward March. Precipitation is the one climatic factor important in reducing the red spiders during the spring and summer.

(Fig. 5.) During the summer in Florida drenching and frequent rains usually prevent the red spiders from establishing themselves on the trees. During late fall and winter and early spring it rains seldom, and the interference with the activities of the red spider is slight.

PREDATORY ENEMIES.

A number of predatory enemies of the avocado red spider aid at various times in keeping down the species on the avocado to a small degree.

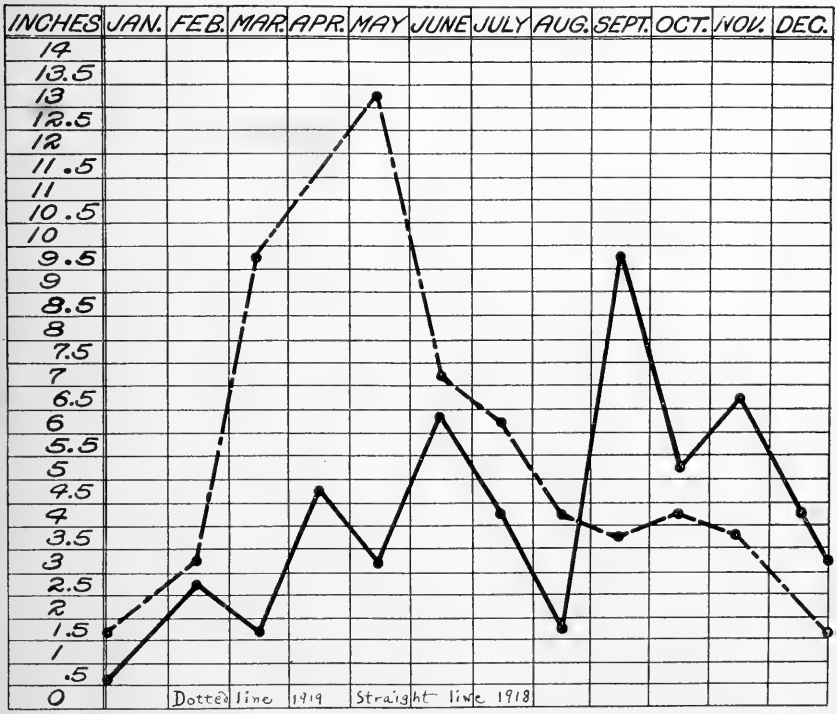

FIG. 5.—Precipitation chart for the years 1918 and 1919 in southern Florida.

Scolothrips sexmaculatus Pergande is one of the predatory thrips and is not abundant during the height of the red-spider season. Nevertheless it is present doing its share of destruction. It is a light-colored thrips possessing six dark spots on its body. It feeds on the red spiders in both the larva and adult stages.

Chrysopa lateralis Guer. is one of the so-called lace-wing flies and is predatory in the larva stage on the red spider. The larvæ, while feeding and wandering about the foliage in search of their prey, carry with them a protection consisting of foreign material, such as cast red spider skins, etc. The larvæ have a voracious appetite and

possess powerful jaws with which they attack their prey. This species is quite beneficial.

Scymnus utilis Horn.—The most important enemy of the red spider found up to this time is a very small black ladybird beetle

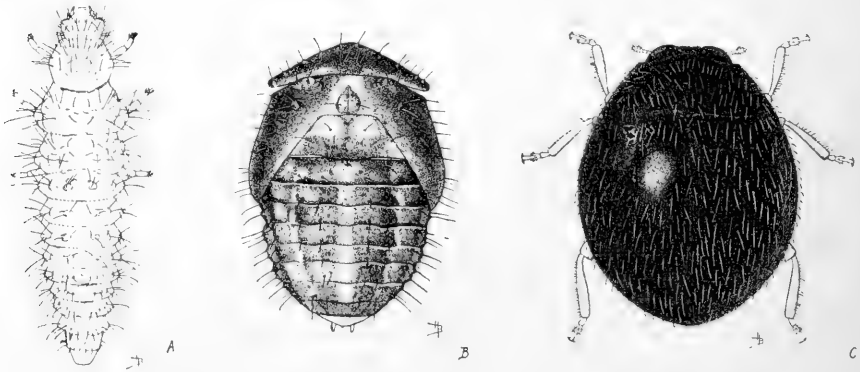

FIG. 6.—*Scymnus utilis: a*, Larva; *b*, pupa; *c*, adult. Greatly enlarged.

(fig. 6, *c*) about $\frac{1}{16}$-inch long. With the beetles may be found their dark brown larvæ (fig. 6, *a*), also feeding on all stages of the red spider.

Scymnus kinzeli Casey is another ladybird beetle found feeding in both the larva and adult stages on the red spider. It is larger than

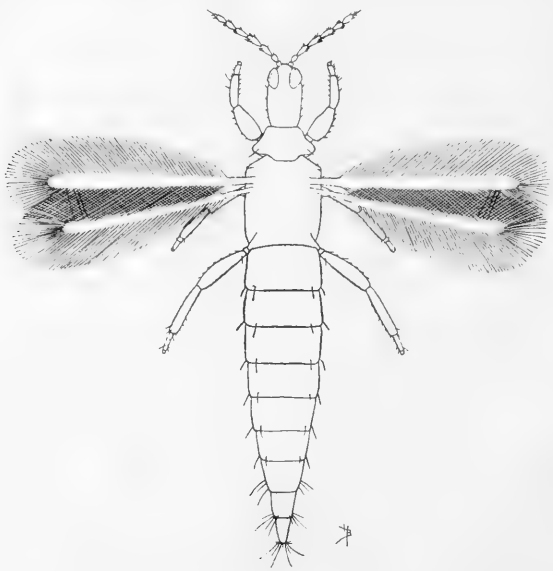

FIG. 7.—*Leptothrips mali:* Adult thrips. Greatly enlarged.

the former, the abdomen is black, and the head reddish. It is not a very abundant species and is not as beneficial as the former beetle.

Leptothrips mali Hinds is a large black thrips (fig. 7) predatory in both the larva and adult stages, and when present is very active

on the foliage in search of red spiders. It is not very abundant at any time.

SPRAYING EXPERIMENTS.

A number of insecticides have been tried out to ascertain their relative merits against the avocado red spider. The experiments were all conducted cooperatively with growers and in groves where the mite was abundant.

FIG. 8.—Power duster in operation using sulphur dust against the red spider in an avocado grove.

SULPHUR DUST.

An impalpable sulphur dust was tested on both the West Indian and Guatemalan races of avocadoes. In applying the material a power duster (fig. 8) was used. The sulphur proved to be very effective against the species, killing 99 per cent of the spiders, and remaining effective on the foliage over as long a period as did any of the liquid sprays tested. Experiments with this material showed that it was not necessary to apply the sulphur dust when the foliage was wet with dew. Where an avocado grower has a large acreage and the red spider is the only serious enemy to contend with, the dusting method is very practical and by far the quicker method. At the present time, however, the avocado grower has other insect pests with

which he has to contend, making it necessary to use liquid insecticides in combination with a sulphur spray in some form for their control. Up to this time the writer has not found it practical to use a combination of sulphur dust and 40 per cent nicotine sulphate against the insects of the avocado.

LIME-SULPHUR CONCENTRATE.

In using lime-sulphur concentrate spray on the avocado a number of strengths were tried, e. g., 1 gallon of concentrate to 40 gallons of water, 1 to 60, and 1 to 75. In spraying with lime-sulphur solution it was found through actual count that nothing is to be gained in applying too strong a solution of lime-sulphur to red spiders on the avocado. A strength of 1 gallon of the concentrate to 60 gallons of water proved to be the most efficient, generally killing 99 per cent of the spiders and producing sufficient body as a spray on the foliage to remain effective during the dry season against later hatching young. Under certain conditions applications of 1 to 40 and 1 to 60 were too strong, and considerable damage resulted to the foliage from burning, especially on the south side of the trees. When the temperature is above normal during the winter season, or when the trees do not attain a thoroughly dormant condition, a strength of 1 gallon of the concentrate to 75 gallons of water was found satisfactory. It was also ascertained that it is not necessary to incur the extra expense of adding a spreader of lime-sulphur spray, such as flour paste, glue, or fish-oil soap, because good results were obtained without it.

COMMERCIAL SODIUM SULPHID.

Commercial sodium sulphid was used at a strength of 2 pounds to 50 gallons of water. It was ascertained that this spray killed approximately 95 per cent of the red spiders present. Because of its chemical composition, however, the spray did not dry thoroughly on the foliage. The hydroscopic condition so formed permitted the spray covering the eggs and foliage to be readily washed off by succeeding rains, and nothing remained to destroy the hatching young.

NICOTINE SULPHATE CONTAINING 40 PER CENT NICOTINE.

At times the red spiders make their appearance during the fall before the fruit is picked. At this time it is not advisable to use any of the sulphur sprays, as they adhere to and discolor the fruit. By using 40 per cent nicotine sulphate at the rate of 1 part to 900 parts of water, with the addition of 2 or 3 pounds of fish-oil soap to each 100 gallons of the diluted spray as a spreader, satisfactory results were secured. The spray, however, proved to be effective only

temporarily, as none remained on the foliage to destroy the young on hatching.

SPRAY ROD VERSUS SPRAY GUN.

In making a comparison of the spray rod (fig. 9) and the spray gun (figs. 10 and 11) it was found that the latter gave better satisfaction against the red spider. Where an orchardist is short of help considerable benefit can be derived by using the spray gun, as the spray operator can cover the ground much faster than when using

FIG. 9.—Spraying in an avocado grove with spray rods.

the spray rod. As the red spider works on the top of the foliage the operator can stand off a short distance from the tree, and with the use of the spray gun can spray from the bottom to the top of the tree by turning the handle of the gun which changes the spray from the fan or fog spray (fig. 10) to a long-distance spray (fig. 11).

The writer has found that growers in using the spray gun often neglect to change the disk in the nozzle frequently enough and wonder why they can not maintain sufficient pressure while spraying. The operator should watch the opening of the disk in the nozzle of the gun, and should replace it when it is worn.

CULTURAL METHODS IN THE GROVE.

Clean culture does not play an important part in the control, as this species does not infest weeds or plants in or about avocado groves. Orchards mulched in various ways in southern Florida were found to be less infested with the red spider as a rule than those where clean culture was practiced. The avocado seems to thrive better where mulching is practiced and the moisture is conserved. Red spiders generally like dry conditions such as are afforded in

FIG. 10.—Spraying in an avocado grove with spray gun, using the fan or big fog spray.

groves where clean culture is followed. This is especially evidenced in seasons of drought during the year.

One factor which influences greatly the abundance and appearance of the red spider in a grove is the vitality of the trees. Nothing is to be gained by allowing trees to suffer from want of proper attention in the way of mulching, plant foods, and culture. Where growers are in doubt about the proper procedure to use in caring for their avocado trees, they should get in touch with either the Plant Introduction Garden maintained by the United States Bureau of Plant Industry at Miami, Fla., or their particular county agent.

RECOMMENDATIONS.

The presence of the avocado red spider on the trees in considerable numbers while the foliage is still green should be a sufficient indication of impending injury to cause the grower to begin immediate application of control measures. The grower should not wait until the foliage attacked becomes noticeably brown prematurely and begins to drop.

During the winter after the fruit has been picked use the liquid lime-sulphur 1 to 60. When the temperature is above the normal and the trees do not attain a thoroughly dormant condition the liquid lime-sulphur should be reduced to 1 to 75.

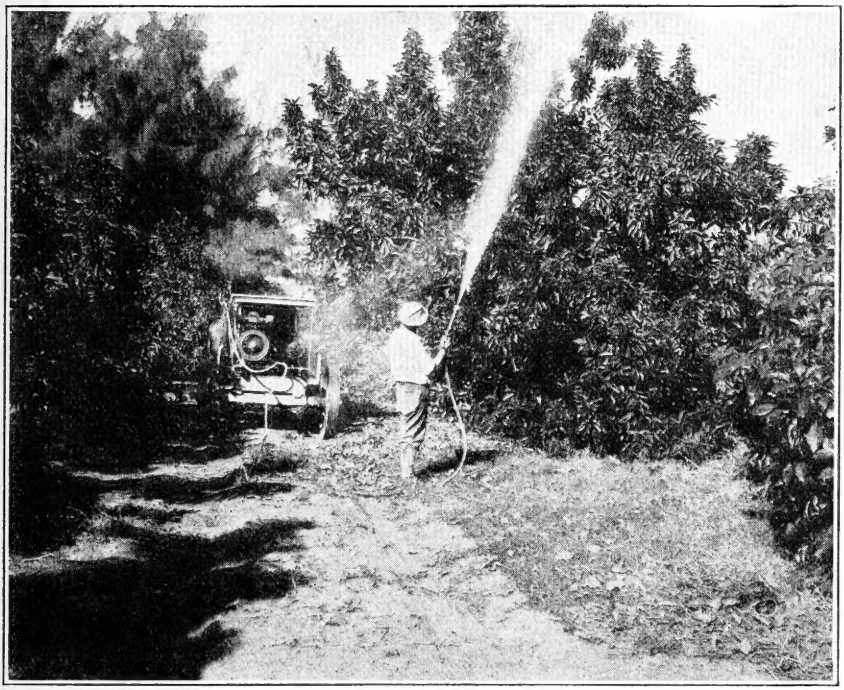

FIG. 11.—Spraying in an avocado grove with spray gun, using the long distance spray.

If the red spiders are present while the fruit is still unpicked in the fall, 40 per cent nicotine sulphate 1 to 900, with the addition of 2 or 3 pounds of fish-oil soap to each 100 gallons of the diluted spray, will give temporary relief and will not discolor the fruit.

Thorough application is a most essential point in combating the red spider.—If haphazard work is performed and much of the foliage left unsprayed, such infested foliage serves as a source of reinfestation to the tree, and the mites will be more in evidence after application than when thorough work has been done.

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